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Project Title
Project Title: Climate, Water Scarcity and Management in Brazil and Chile

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I. Preliminary Materials

A. Abstract

This comparative study examines the use of seasonal climate forecasting in water management in Brazil and Chile, two countries where a better understanding of climate variability may be critical to mitigating the effects of water scarcity. Both countries have initiated broad water reform programs that promote decentralized water resource

management, and in the Brazilian case, integrated and environmentally sustainable management. Legislation in both countries stipulates that water is an economic good for whose use users should pay. Under these circumstances, the use of seasonal climate information can play a critical role in water management by allowing for pro-active planning and decision-making. However, technical and scientific (especially climate) information enters into watershed-level decision making in different ways, varying both with institutional design and pre-existing problem definitions. We must therefore disaggregate these, making it possible to identify and decipher characteristic patterns of combinations and their association with processes and outputs of water management institutions. Institutional patterns act as filters that determine how information is received and used. We have undertaken extensive institutional analysis of the water sector in both countries, focusing on the following research questions: What factors shape the use of technoscientifc information, in particular, climate information in water management decision-making? Does private ownership of water rights make actors more likely to seek out such information? Does use of scientific information support (through increasing transparency and accountability) or hinder (by promoting technocratic insulation) democratic decision-making processes? To answer these questions the project compares the use climate information (along with other kinds of science generated information) across eighteen watersheds in Brazil and three in Chile   The study combines quantitative analysis based on survey data of decision-makers with qualitative methods (in-depth interviews with key informants and documentary research) to investigate the uses (actual or potential) of seasonal climate forecasting in decision-making at the watershed level.

In Brazil, we are collaborating with researchers involved in the Watermark Project, a multi-year study of factors affecting institutional innovation and consolidation of participatory watershed-level management institutions. The project has a commitment to share findings continuously with the groups and organizations being studied including watershed-based committees, government organizations, and the public. In Chile, we are building upon research already in progress within a NOAA funded project comparing the use of seasonal climate forecasting in agriculture and drought planning in the Limarí River basin in Region IV, one of the driest in the country, and two other watersheds, the Maule River and the Ñuble River basins, located to the south of the capital city of Santiago. All three watersheds in Chile share a common institutional framework, but show different levels of annual precipitation. Other varying factors are the existence/absence of reservoirs either for irrigation (in the Limarí) or both irrigation and hydropower (the Maule), levels of economic development, level of conflict, quality of water-users organizations, and patterns of use of techno-scientific information.

B. Objective of Research Project

The goal of this study is to understand how policymakers and other users adopt and apply techno-scientific information, especially seasonal climate forecasting, in the management of water resources in Brazil and Chile. In order to accomplish that, we carried out extensive institutional analyses of the Brazilian and Chilean water management systems. We targeted policymakers, stakeholders (members of river basin committees and resource users), to build a broad database on the perceptions and use of technoscientific information in general, and climate-related information in particular. We aim to carry out institutional analysis at the level of watershed decision-making taking into consideration six sets of variables:

- social political setting (federalism, political culture, level of decentralization)
- nature of the problem (physical characteristics, complexity, level of permanent structures, conflict/crisis)
- Individual information (socioeconomic data, professional characteristics, personal values)
- institutional complexity (Laws, rules, overlapping jurisdictions, accountability, authority)
- organization culture (flexibility, participation, accountability, capacity, resources)
- knowledge 'fit' (perception of relevance, accessibility and availability, role in supporting or hindering decisionmaking)

C. Approach:

Our unit of analysis in both countries is the river basin. We consider the following factors:

a. In each country, we selected watersheds located in regions with comparable geoclimatic characteristics and under similar climatic fluctuations, that is, drought in Northern Chile and Northeast Brazil and flooding in the South/Southeast of both countries. These watersheds are good representatives of the kind climatic stress and ecological conditions existing in a few regions of both countries;
b. Brazilian policymakers in the study area are actively implementing policies to move water management, towards a more decentralized, integrated, participatory and environmentally sustainable watershed-based water management system. Chile has had a decentralized water system since the 1980's, but some policy makers have been attempting to modify the Water Code in order to promote a more ecologically conscientious use of water. The amendment to the water code was finally approved in 2005, so we took advantage of the timing of our second field campaign to carry out research on the potential impacts of these changes (that are aimed at avoiding speculation with water rights and higher environmental protection).
c. In all cases, agriculture and industry (including electricity) are the activities most vulnerable to climate variability;
d. The study regions are prone to drought and flooding associated with seasonal climate phenomena, such as El Niño/La Niña;
e. In both countries, reforming the water management system and reconciling supply and demand from multiple uses has become a pressing issue on the governmental agenda.

We are proceeding inductively, testing loosely defined hypotheses in different socio-economic and institutional contexts. We use a multi-method approach that combines quantitative and qualitative research methods such as surveys, semi-structured, in-depth interviews, secondary analysis of national data, and personal observation, and interpretation of findings in relation to their wider social contexts. We recognize that the two levels of comparison (among different basins in each country and cross-national between Chile and Brazil) adds more complexity to the research. However, although we expect some variability from one national sample to the other, we trust that the richness provided by the ethnography of each of the basins selected for this study will outweigh whatever clarity we lose in general empirical propositions.

The field team has carried out in-depth interviews with policy and decision-makers at the watershed, state, and federal level where relevant for each of the case studies selected. Key informants have been identified through purposeful, opportunistic sampling where individuals "snowball," or refer, to other individuals, and the original list of persons consulted grows according to recommendations of the interviewees themselves. In this case, snowball selection is appropriate because, rather than formal hypothesis testing, the main goal of such interviews is to gauge policymakers' perceptions of their constraints and opportunities for using climate information in decision-making. In addition, in collaboration with the Watermark, we designed and applied a survey of river basin members across eighteen basins in Brazil, querying several aspects of the new water management structure, including use of different types of technoscientific knowledge.

We expect the research will contribute to scholarship in Policy Sciences, Environmental Sciences, Social Studies of Science, and environmental studies within the social sciences more generally. Our focus on information flows and the interplay of technical and practical knowledge in institutional development, a long a research focus for Lemos, has significant importance for the study of science and society and for development studies. By paying a great deal of attention to the development of informal practices in organizations, as well as to information flows and decision-making within and among them, we hope to contribute to the literature on political learning to which Keck has made significant contributions. By examining of the complexity/simplicity both of the organizations that deal with hydropower generation—to which the Chilean law give precedence during crises, and which is present in one of the three Chilean basins—and of other organizations related to water management in Chile (e.g., irrigators associations, some few farmers who receive real-time climate information from the local university), we hope to contribute to increase our understanding of the institutional mechanisms shaping water management under free-market conditions.

D. Description of any matching funds used for this project.

This study collaborates with the Watermark project in Brazil, coordinated by Keck. The Watermark Project was set up to take advantage of the simultaneous organization of decentralized watershed management institutions in most Brazilian states. It has received funds from the McArthur foundation, Hewlett Foundation and the Brazilian Ministry for Science and Technology (through CT-Hidro). It aims to generate broadly comparative data, over time, about a set of questions of interest to both scholars and practitioners, and to provide a space for an ongoing exchange of views and information. In addition, this study leverages funds with NSF through a grant awarded to Lemos.

II. Interactions

A. With policymakers: in Years One and Two (Summer 2004 and to a lesser extent 2005), we interviewed water and reservoir managers, and Watershed Committee members in the watersheds selected in addition to two other watersheds, one in the state of Bahia and another in the state of Rio Grande do Sul, taking advantage of comparative research being carried out by two PhD students involved in the project. In addition, the Watermark Project involves constant interaction with those policymakers who participate in it, most of whom have been deeply involved with the water reform project in Brazil. In 2006, the Watermark was awarded a new grant from the Brazilian government (through CT-Hidro) to organize a series of stakeholder workshops to discuss the progress of the water reform and report the results of the Watermark survey to the targeted basins. The workshops are planned for 2007. In Chile, the research team is interacting closely with the National Commission for Irrigation. The NCI is in charge of the administration of several economic instruments that the government has designed to improve efficiency of irrigation water utilization. This agency is also implementing a program aimed at fostering water users' organizations and use of technical information. In this sense, the NCI has added research questions to our project and provided the research team with important data (names of users, GIS data, organizations to interview), which we hope will increase applicability of our findings by decision makers. The research team also participated of a workshop organized by UN Economic Commission for Latin American and Caribbean (ECLAC) and *Dirección General de Aguas* (DGA) to discuss the Water Code amendment.

B. With the climate community: the study also includes interviewing climate forecasters located in Santiago de Chile and in a few of the watersheds selected in Brazil.

C. With other NOAA projects: the study builds on previous research funded by NOAA in which both Leon and Lemos have been involved. It is also collaborating with another on-going project (originating at IRI) to understand the use of seasonal climate forecasting in NE Brazil (Kenny Broad, PI).

III. Accomplishments

A. Brief discussion of research tasks accomplished. Include a discussion of data collected, models developed or augmented, fieldwork undertaken.

- The research team carried out an extensive literature review and collection of secondary data to support the research project. These data have been used in the writing of articles already submitted or to be submitted to peer-review publications.

- Several students funded or supported by this projected completed or are in the process of completing their graduate degrees: (five MSc theses at the University of Michigan have been or are being advised by Lemos, of which two –Lori Kumler and Jonah Smith have been completed—and three PhD dissertations at Johns Hopkins by Keck, of which one—Ricardo Gutierrez has been completed. In Chile, fieldwork in each of the three studied basins was undertaken by a student directed by León: in Limarí Rodrigo Fuster completed a MSc at the Universidad Autónoma de Barcelona; in the basins of Maule and Ñuble, José Miguel Arriaza and Fabiola Arcos have completed the project requirements for their degree in Natural Resources Engineering at the University of Chile).
- Keck and Lemos have carried out summer field research in Brazil in 2004 and 2005. With the support of students, eighteen key informant interviews were carried out in the Itajaí basin, sixteen in the Lower Jaguaribe basin, and twelve in the Paraiba do Sul. An additional twelve interviews in Ceará and twenty-two in the Paraíba do Sul have been carried out by Master's students to complete their projects.
- Analysis of the Watermark survey (partially funded by this project). Data from the survey was finally available for analysis by the end of 2005. The survey tests the significance of several different kinds of variables for explaining participation and the ability to reach agreement on goals, including individual characteristics and beliefs (socio-economic status, area of specialization and worldviews), organizational processes (such as the role of leadership and the use of technical information), external context (such as socio-economic conditions). It also collects data helping measure the level of democracy and effectiveness of the organizations, recognizing that these characteristics cannot be fully captured through survey analysis and must be complemented with qualitative work. The survey contains modules on socioeconomic characteristics, organization, participation, world views, cohesion, and use of information. The Information Use module was designed specifically to address questions pertinent to this study, including past use of seasonal climate forecasting, perception of potential future use, perception of its relevance, accessibility and skill, and perception of impacts of the use of technical information on issues of democracy, accountability and ability to make decisions.
- To ensure comparability, the Chilean research team utilized the original survey designed in Brazil. Due to the differences in the institutional setting and non-existence of the "basin" as a management unit, the survey was adapted to the local conditions.
- Leon supervised and advised the design of José Miguel Arriaza's project, a Natural Resources Engineer final research project, in the Maule River basin. In this basin key stakeholders were contacted in order to initiate the "snowballing" process. For this purpose, the research team attended a technical meeting hosted by the University of Talca during late 2003, where fresh fruit growers who are current users of techno-climate information provided by that university were contacted.

- Rodrigo Fuster, faculty at the University of Chile and currently a graduate student in the Environmental Sciences Ph.D. Program at the Universidad Autonoma de Barcelona, Spain, completed the interviewing process in the (dry) Limari basin in July 2005. Fuster was co-PI of a IWMI funded project that examined the relationship between public investment in irrigation infrastructure and the decrease of rural poverty in this basin. Hence, he already has a deep knowledge of the basin's reality.
- Leon also supervised and advised the design of Fabiola Arcos' project, a Natural Resources Engineer final research project. This study was completed in the Ñuble basin. This basin has a low level of conflict since is primarily devoted to agriculture. Nonetheless, lack of climate information has deterred investments in agriculture since water supply decreases sharply by the end of November. Water availability for irrigation is limited from November all through May.
- At the federal level, the team has interviewed several of the technical figures within the water management public organizations.

B. Provide two or three overheads of key research results in bullet form.
(Suggested Limit: 5 bullets per page)

C. Elaboration of key findings (i.e., how this research advances our scientific understanding) (Text Limit: 5 pages)

This project is constituted by two broad components. First, an ethnographic analysis of seasonal forecast use by water managers across six river basins in Brazil and Chile. This component uses in-depth interviews to identify the opportunities and constraints for the incorporation of SCF in water managers' decision making regarding the management of bulk water (both for water supply and hydroelectricity) and response to disaster (flooding and drought). The second component uses survey data to understand seasonal climate forecast use in the context of the decentralization of water management in Brazil and Chile.

For the sake of organization, this section is divided into three sub-sections:

a. Institutional analysis and mapping of the factors shaping technoscientific knowledge by water managers in Brazil.

In Brazil, we queried members of river basin councils, which are stakeholder organizations whose mandate include debating and planning for bulk water management, the establishment of user fees and water zones as well as conflict resolution. To date, these committees have functioned in parallel with the public water management system. Their relationship has been characterized by different levels of collaboration, authority and conflict across different basins. Their integration depends on several institutional and organizational characteristics but while water managers are responsible for the day to day management of water resources, river basin committees debate and design long-term water management planning and governance at the river basin level. This division of work is reflected in the way these two groups of decision makers perceive and report their use of climate information in this project. While water managers are much more precise in identifying specific ways in which they use (or not) climate information (for example, in hydrometerological or streamflow models), river basin council members perceive use in a broader sense, that is, how information about an upcoming El Niño and its potential impacts of the river basin sift through their debate and planning at the council level.

Taking into consideration this institutional make up, this portion of the research explored use of seasonal climate forecasting in three river basins in Brazil. In the Lower Jaguaribe, the state water agency (COGERH) is in charge of reservoir management with the support of two participatory councils. The first is the Users' Commission that meets periodically to evaluate and plan for water use of the river basin three main reservoirs (Orós, Banabuiú, and Castanhão). As a decision support tool, técnicos from COGERH build simple reservoir scenarios where different rates of discharge are represented. Although zero rainfall is built into the scenarios, técnicos use climate information (especially ENSO forecasting) to modulate how conservative their advice to users will be during the public meetings (personal interviews 2004, 2005). The scenarios are presented in well-attended (over a hundred participants) users' meetings held twice a year and there is evidence that the use of technical information may have both improved water use sustainability and the quality of stakeholder participation (Lemos, 2007). In these meetings, water users engage in heated debates in which they try to reconcile their water needs with water availability according to the different case scenarios provided by COGERH.

In the PSRB, reservoir management has been much less participatory although the post-water reform decisionmaking process can be considered significantly more transparent than in the past (Formiga, Kumler and Lemos, 2007). Because the Paraíba do Sul River crosses three states—São Paulo, Rio de Janeiro, and Minas Gerais, it is under federal jurisdiction. The PSRB has also the most advanced and resource-rich river basin committee, the CEIVAP and its operational agency AGEVAP. Within the PSRB, one contentious issue is the transfer of water resources across basins, from the river's headwaters in the state of São Paulo to the city of Rio de Janeiro (located outside the basin) through a system of reservoirs and dams. Besides supplying water to the city of Rio de Janeiro, the system also generates electricity as part of Brazil's energy matrix and normalizes river flows to control flooding. The transfer has been managed mostly by the hydroelectric system and its main decisionmaking organization, the Operador Nacional do Sistema (The National Operating System), a private organization funded by the electricity industry. ONS has been very proactive in innovating and has invested resources in procuring climate knowledge (from Universities) to inform its decisionmaking. ONS insertion with the new water management system has been somewhat marginal. However, in the drought crisis on the beginning of the 2000s, ONS did collaborate with CEIVAP to manage resources and reconcile lower levels of water availability with the needs of both up river communities in São Paulo and water supply in Rio de Janeiro (Kumler and Lemos, in review).

In the Itajai, where resources are limited and the river basin committee implementation is considerably less advanced than in the other two basins, a simple model has been used to manage flooding. However, a severe financial crisis has negatively affected the monitoring and operation systems, which have been mostly inactive. Moreover, differently from the other two basins, the IRB has failed to implement a water charging system and therefore has generated virtually no resources to fund studies that are more sophisticated or modeling activities.

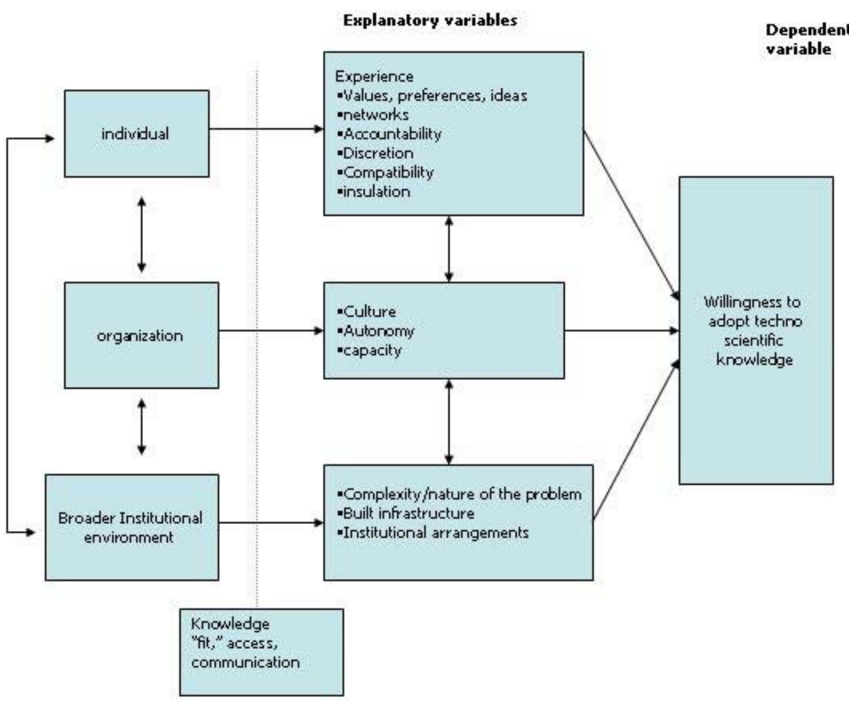
Preliminary findings of this project show that a number of factors influence the willingness of individuals to adopt or reject new knowledge into their decision making processes. Based on data collected from water managers, Lemos has proposed a simplified model, identifying formal and informal institutional arrangements that shape their willingness to incorporate climate information in decisionmaking. In the model, institutions refer to norms, practices, formal and informal rules and apply to both organizations and decision systems. At the individual level, several factors shape managers' willingness to consider new decision tools. First, ideas—defined as principled beliefs affecting action (Lemos and Oliveira 2004)—may influence an individual's willingness to use knowledge-based tools. Here managers' beliefs in terms of their mission, their clients, and the broader impact of their decisions affect the way they perceive new decision tools. For example, in politically charged decision environments, managers may be tempted to rely on expert knowledge and "technological fixes" to insulate decision making from political meddling (Lemos 2003). In decision environments where managers attach high value to routine and reliability, they may avoid introducing new untested tools (a finding consistent with Rayner et al. 2002's NOAA funded project).

Second, professional background, past experiences, and the policy networks managers belong to influence the way they make decisions, either by providing examples (i.e. managers will emulate other managers) or by facilitating communication and exchange of experiences between members. Users' experience with other kinds of innovation and their outcomes will affect their willingness to experiment. Hence, users whose past experiences yielded positive outcomes will be more open to the advent of new tools. Conversely, users who have been "burned" by innovation in the past will be less willing to try new things. Third, knowledge characteristics, especially the extent to which managers perceive new decision tools as relevant, credible and available may affect rates of adoption. Fourth, perception of risk and levels of discretion and accountability influence willingness to adopt innovation. Thus in times of perceived crisis, managers were more willing to use climate information to modulate their risk averseness. Related with degrees of risk averseness are levels of discretion and accountability. Managers with high levels of discretion and low levels of accountability are likely to be considerably more willing to innovate since they are either able to "shift the blame" of failure elsewhere or they perceive any negative consequences of their actions as unlikely to affect them or their position negatively.

At the organizational level, three variables: culture of risk, experience, and capacity have been considered. Like the managers themselves, some organizations will develop a higher or lower culture of risk based both on their level of discretion and accountability as well as past experiences with innovation. Routines are more often predicated on experience than on anticipation of the future and experience is adapted incrementally in response to "feedback from outcomes" (Levitt and March 1988, p. 320). Finally, technical and human capacity are also critical to organizations' ability to adopt innovation.

At the decision environment/institutional level, flexibility may be a function of the complexity and the nature of the problem (water scarcity, water quality, and water transfer; multiple uses and conflict) and built-in infrastructure. For example, decisionmakers may be especially encouraged to use climate information for planning purposes in times of crisis (i.e. reservoir management, water budgets for interbasin transfers, etc.). Similarly, the more built-in infrastructure, the more inflexible maybe the system for change. Finally, characteristics such as the formal institutional arrangements (legislation, nested rules, rates of institutional change) regulating water management and the informal norms and practices that may constrain water related decision making critically shape the flexibility of the system to adopt new decision tools. Figure 1 depicts the simplified model.

Figure 1 Simplified Institutional model



b. Climate information use at the river basin level in Brazil.

This portion of the project quantitatively analyzes the use of different technoscientific knowledge at the river basin level, in particular climate knowledge. Tables 1 and 2 show the river basins included in the research and the level of climate information use reported by river basin committee members, respectively.

River basins	Date Created	Size of Basin (km2)	Number of Municipalities
Lagoa da Conceição Committee (SC)	2001	80	1
Pirapama Committee (PE)	1998	600	7
Litoral Norte Committee (SP)	1997	2000	4
Gravataí Committee (RS)	1989	2020	9
Lagos São João Consortium	1999	3800	12
Alto Tietê Committee (SP)	1998	5650	34
Sapucaí Mirim Grande Committee	1996	10873	23
Pará Committee (MG)	1994	12300	36
Araçuaí Committee (MG)	2000	14621	22
Piracicaba Consortium (SP)	1993	15320	71
Itajaí Committee (SC)	1998	15500	47
Santa Maria Committee (RS)	1993	15739	6
Tibagi Consortium (PR)	1989	24711	52
Velhas Committee (MG)	1998	28867	51
Itapicuru Consortium (BA)	2000	36440	54
Paracatu Committee (MG)	1998	45600	21
Paraiba do Sul Committee (RJ, SP, MG)	1997	55550	180
Baixo Jaguaribe Committee (CE)	1997	80547	80

Table Two: Reported Climate Forecast Use in the Basin

River Basin Councils	Number of Interviews	% of member who reported climate forecast use in within the Committee	% of member who reported weather forecast use within the Committee
Baixo Jaguaribe	29	75,9	79,3
Itapicuru	25	48,0	48,0
Pirapama	17	47,1	47,1
Alto Tietê	30	36,7	36,7
Araçuaí	14	14,3	14,3
CEIVAP	59	67,8	69,5
Lagos São João	16	43,8	37,5
Litoral Norte	34	35,3	41,2
Pará	26	53,8	53,8

Paracatú	16	43,8	25,0
Piracicaba	17	88,2	82,4
Rio das Velhas	24	20,8	12,5
Sapucaí Mirim	23	30,4	43,5
Gravataí	27	29,6	22,2
Itajaí	58	62,1	63,8
Lago da Conceição	25	16,0	8,0
Santa Maria	29	65,5	55,2
Tibagí	32	28,1	37,5

Table 3: Committee members' perceptions of climate information

	Relevance of climate info (score 1-10)	Tech info makes decisions easier	Info is available	Info accessible	Unequal tech knowledge	Unequal economic power	Unequal political power
CEIVAP	7.6	100.0	64.4	72.9	64.4	52.5	57.6
Itajaí	7.1	93.1	68.4	77.6	75.9	34.5	67.2
Alto Tietê	6.5	80.0	40.0	36.7	83.3	40.0	60.0
Araçuaí	6.8	100.0	28.6	64.3	78.6	35.7	50.0
Velhas	6.9	87.5	43.5	54.5	82.6	37.5	41.7
Pará	7.1	92.0	57.7	73.1	69.2	23.1	50.0
Pirapama	7.2	94.1	52.9	70.6	88.2	52.9	47.1
Sapucaí Mirim	5.9	91.3	82.6	69.6	60.9	26.1	65.2
Litoral Norte	6.9	88.2	82.4	78.8	44.1	14.7	33.3
Baixo Jaguaribe	7.8	93.1	32.1	86.2	79.3	27.6	62.1
Paracatu	7.1	87.5	43.8	37.5	37.5	31.3	31.3
Lagoa da Conceição	5.9	83.3	25.0	50.0	88.0	24.0	54.2
Gravataí	7.5	100.0	77.8	59.3	66.7	11.1	44.4
Santa Maria	8.0	96.6	93.1	82.8	72.4	31.0	27.6
Piracicaba	7.3	88.2	94.1	64.7	35.3	52.9	52.9
Tibagi	6.8	96.7	51.6	61.3	61.3	35.5	77.4
Itapicuru	8.2	96.0	76.0	88.0	64.0	32.0	20.0
Lagos de São João	6.8	100.0	100.0	100.0	43.8	6.3	43.8
Total	7.1	92.9	62.7	69.4	67.5	32.6	51.4

The next step will be the identification of the factors that influence the rate of use across the sample of river basins selected. At present, Lemos (with Don Nelson) is working on an article correlating reported data use with several independent variables (including river basin committee members' gender, level of education, income, professional background and origin—whether a representative of the users, civil society or public sector). Other variables being analyzed are size and age of river basin councils, level and mode of access of climate information (easily available, easily understood and where accessed—radio, interned, scientific publications, newspapers, etc.) to understand the factors influencing different levels of reported knowledge use. In a second phase, we will correlate reported levels of use with different sets of independent variables (Table 3), seeking to understand how council members perceive the intersection between technoscientific information (and particularly climate information) and democratization of decision making. We explore two hypotheses, first that knowledge is perceived as positively contributing to decision making, and second, that knowledge is perceived as a source of inequality between council members. For example, in the Lower Jaguaribe river basin, although river basin committee members believe that technical information is useful and helpful to their decision-making, they find it is neither widely available nor easily accessible and understandable. They also perceive power within the River Basin Committee as strongly skewed in favor of those who have technical background to use this kind of information over other actors. Hence, though 93.1 percent of the members report that technical information makes decision-making easier, only 32.1 percent perceive it as available to all members. Moreover, members surveyed pointed out that the main constraint to the democratization of decision-making within the Committee is the disparate level of knowledge between técnicos and general members.

Table 4: sets of independent variables

Independent Variables	Watermark Survey Questions
Participation	# of meetings attended; # of times members speak in meetings; # of times members make proposals; # of times members facilitate negotiations; level of participation in council's working groups.
Accountability	Level of discretion among members to make decisions; # number of times members report back to their organization; # of times members report back to the segment they represent; means through which members have been chosen (representation).
Transparency	Member's perception of the level of transparency in council's decision-making process; level of availability of knowledge;
Inequality	Level of accessibility to knowledge; perception of inequality in the distribution in economic and political power; perception of level of democracy within the council; perception of level of obstruction;

	perception of the level of conflict

c. Climate information use in Chile:

In Chile, our results show that techno-climatic information has penetrated significantly the processes of water management by private companies (agricultural, hydropower, utilities) and public agencies (mainly the Dirección General de Aguas (General Water Directorate) and the Dirección de Obras Hidráulicas (Water Works Directorate). Within private companies, climate information is contained within a pool of technical information that these organizations utilize for their managerial and productive purposes. The pool includes information on legal, economic, environmental (e.g., water quality) issues and infrastructure needs. Within these users, climate information has become a relevant technical input. Thus, firms have developed and/or added climate information to their decision making process and developed a set of human and technical resources to take advantage of this kind of information. One key example are firms in the Maule basin that are linked to foreign markets. In these firms, the process of penetration and utilization of techno-scientific information appears to be consolidated. Thus, some companies have developed the capacity of generating climate information in an autonomous fashion, which provides them with an ample competitive advantage for the development of their economic activities.

Within the irrigation associations, addition and utilization of climate information is weaker than firms and public organizations. This is because the level of development of the organizations is feeble, and the participatory processes, commitment and responsibility of members fragile. Thus, these associations have been unable to develop an adequate human, financial and technical resources management strategy and consequently modernize the water management process. This limits the organizations' development and their capacity to utilize technical information. By the same token, overall weakness leads to restricted dissemination and use of information, which in turn, results in a limited impact over the productive activities of the members. Additionally, members of these organizations generally do not visualize technical information as a key input in the decision making process. A related issue is the lack of financial resources that puts them in a dependent position vis-à-vis public agencies in charge of generating and disseminating technical information. This dependency limits the managerial process within irrigators associations.

The situation described above relates to the forms of participation within the irrigators associations and water communities Their culture is characterized by delegation, passive membership and a weak commitment towards the organizations´ objectives and functions. Hence, the decision process tends to concentrate within the managers of the organizations. In this sense, there is a tendency for the emergence of individuals who concentrate in their hands, and on the hands of their closest collaborators, the decision making process. This generates a vicious circle in which managers are unable to stimulate participation of members, and these do not get involved in the organization because they do not foresee the objectives of the organization and the way in which their involvement could result in an improvement of their economic situation. Within this framework, charismatic leadership emerges as the only plausible way to break the circle and to bring leaders and constituencies closer. However, these leaderships expose the organization even more to centralized decisionmaking that mostly reflects their own vision at the expense of the organizations’ goals. Currently, managers tend to remain in their posts over long periods of time and both renovation of cadre and replacement teams seem not to be in short term horizon.

Within public organizations and private companies is where adoption of techno-scientific information is more strongly related to the decision making process. These organizations are thus able to develop complex innovations. In those organizations where the adoption of information is weaker (such as in irrigators organizations and water communities), the type of innovation is simpler. This, in practice, allows for a distinction between organizations that utilize technical information as a fundamental resource (complex innovation) and others (irrigators) that are rooted in the existence of tangible goods (like e.g., infrastructure, canals, etc.).

The modernization process in public institutions has resulted in these services having to generate technical information on basin-level hydrology. Thus, these organizations handle their own technical information in order to manage water and water-rights. Given the public nature of these organizations, they are required to disseminate information they produce among users within a basin. Dissemination exemplifies how traditional bureaucratic processes combine with more modern ones. While production of information is highly dynamic and fast, dissemination works at a slower, bureaucratic pace, which tends to decrease access to those who need technical information in their decision making. A relevant issue of the modernization process of public agencies is decentralization. Study findings show that DGA, DOH and CNR have developed user satisfaction-oriented model that responds to their specific demands; these models vary from one basin to the other. This process is, however, heterogeneous: some agencies are still highly centralized in relation to e.g., the design and operation of projects and programs, as in the CNR, while others like DOH and DGA show higher local autonomy.

Moreover, in Chile, the analysis of quantitative data allows for the structuring of different categories of results in indicators. These indicators are the following:

- Size of the organizations: Organizations of different size are capable of mobilizing different amounts of resources. The bigger the organization, the larger the amount of resources. This applies especially for private organizations. Thus, in basins where fresh produce are exported and hence wealth is higher, firms have the ability to procure and/or generate climate information.
- Professional human resources: the degree of technical qualification of human resources involved in the studied organizations is an issue related to the capacity of searching and using techno-scientific information in the managerial process of the organization.
- Appointment of managers and technicians: Many positions in Chile are filled through public calls. In such cases, there is a more complete evaluation of the candidates´ capacities and therefore a more formal process.
- Use of technical information within the organization: shows how much technical information is utilized within organizations dealing with water mangament.
- Access to information: there are factors that hinder access to information within the organizations. Members of different organizations enjoy degrees of access and freedom to use information, and to disseminate it among users communities. With

better access to information, there is a better consideration of the right to information, and possibly, more democracy within the organizational culture.

- Degrees of separation between decision making and implementation: there is an increased complexity in the organization when these functions are separated.

Flexibility in decision making:

- Decision making styles: the decision making process can include different degrees of participation. With more participation, the organizations tend to be more inclusive and open to the constituencies.
- Information dissemination within the organization: when information is shared among members of an organization there is a higher degree of penetration and use of technology. Organization members share knowledge as a part of their organizational common sense. This process can be denominated as informatization of the organization's culture. Whenever there is an increased degree of dissemination, there is a higher probability of an informatized organizational culture and a higher appreciation of information.
- Use of information technology: The higher its utilization, the higher the penetration of technology and the better the communication within the organization.
- Relationship with the community: organizations have different approaches regarding their relationship with the community and networks. The higher the degree of openness to the community, the higher the chance of enjoying good collaborative networks.

The following table summarizes our findings in relation to the indicators shown above. The last column to the right contains a ranking of the actors in terms of the indicator.

Table 1. General classification of organizations in study area in Chile by indicators

Indicator	**Category**		**Percentage**	**Ranking**
Organization size (contrasts % micro-organizations and % large organizations)	Basin	Limarí	23,1/ 0	**Maule**
		Maule	6,3/ 18,8	**Limarí**
		Ñuble	56,3/ 0	**Ñuble**
	Usuer	Irrig. Assoc.	41,4/ 0	**Companies**
		Companies	33,3/ 50	**Public Organizations**
		Pub. Org.	10/ 0	**Irrigation Associations**
Professional human resources (% of staff members with university degree)	Basin	Limarí	84,6	**Limarí**
		Maule	75,0	**Maule**
		Ñuble	53,6	**Ñuble**
	User	Irrig.	58,6	**Companies**

		Assoc.		
		Companies	100	**Public Organizations**
		Pub. Org.	90	**Irrigation Associations**
Appointment of staff (use of public calls to fill managerial and technical positions)	Basin	Limarí	30,8	**Ñuble**
		Maule	20	**Limarí**
		Ñuble	31,3	**Maule**
	User	Irrig. Assoc.	50	**Companies**
		Companies	83,3	**Public Organizations**
		Pub. Org.	80	**Irrigation Associations**
Use of technical information (relevance of utilization of technical information within organizations)	Basin	Limarí	84,6	**Maule**
		Maule	100	**Limarí**
		Ñuble	68,8	**Ñuble**
	User	Irrig. Assoc.	75,9	**Companies/ Inst. Públicas**
		Companies	100	**Irrigation Associations**
		Pub. Org.	100	
Evaluation of information utilization intensity (% of answers: technical information increases understanding of problems and decision making)	Basin	Limarí	76,9/ 69,2	**Maule**
		Maule	93,3/ 86,7	**Ñuble**
		Ñuble	87,5/ 87,5	**Limarí**
	User	Irrig. Assoc.	82,8/ 75,9	**Companies**
		Companies	100/ 100	**Public Organizations**
		Pub. Org.	90/ 90	**Irrigation Associations**
Access to technical information (% of organizations that easily access technical information for water management)	Basin	Limarí	81,8	**Maule/ Ñuble**
		Maule	100	**Limarí**
		Ñuble	100	
	User	Irrig. Assoc.	90,0	**Companies**
		Companies	100	**Public Organizations**
		Pub. Org.	100	**Irrigation Associations**
Separation between decision	Basin	Limarí	15,4/	**Maule**

making and execution (% organizations where decision making and execution are not separated)			69,2	
		Maule	71,4/ 21,4	**Limarí**
		Ñuble	12,5/ 75	**Ñuble**
	User	Irrig. Assoc.	25,9/ 66,7	**Companies**
		Companies	100/ 0	**Public Organizations**
		Pub. Org.	20/ 60	**Irrigation Associations**
Formality of decision making (% of organizations in which the process is formal)	Basin	Limarí	92,3	**Limarí**
		Maule	66,7	**Maule**
		Ñuble	50	**Ñuble**
	User	Irrig. Assoc.	69,0	**Companies**
		Companies	20,0	**Irrigation Associations**
		Pub. Org.	90,0	**Public Organizations**
Decision Programming (contrasts % of organizations that plan decisions, and % of organizations that make no difference between planned and spontaneous decisions)	Basin	Limarí	30,8/ 61,5	**Maule**
		Maule	80,0/ 0	**Ñuble**
		Ñuble	43,8/ 18,8	**Limarí**
	User	Irrig. Assoc.	48,3/ 27,6	**Companies**
		Companies	80,0/ 0	**Public Organizations**
		Pub. Org.	50,0/ 30,0	**Irrigation Associations**
Decision making style (contrast % of organizations with participation and those which are autocratic in the decision making process)	Basin	Limarí	69,2/ 30,8	**Limarí**
		Maule	60,0/ 20,0	**Maule**
		Ñuble	50,0/ 37,5	**Ñuble**
	User	Irrig. Assoc.	51,7/ 37,9	**Companies**
		Companies	100/ 0	**Public Organizations**
		Pub. Org.	60,0/ 20,0	**Irrigation Associations**
Internal Dissemination of information (contrasts % of organizations that clearly	Basin	Limarí	72,7/ 27,3	**Ñuble**
		Maule	66,7/	**Limarí**

define the role of dissemination and % of those that do not)			33,3	
		Ñuble	81,3/ 18,8	**Maule**
	User	Irrig. Assoc.	69,6/ 30,4	**Companies**
		Companies	100/ 0	**Public Organizations**
		Pub. Org.	80,0/ 20,0	**Irrigation Associations**
Internal use of information technology (% of penetration and utilization of information technologies within organizations)	Basin	Limarí	36,4	**Limarí**
		Maule	30,0	**Maule**
		Ñuble	12,5	**Ñuble**
	User	Irrig. Assoc.	8,3	**Companies**
		Companies	66,7	**Public Organizations**
		Pub. Org.	50	**Irrigation Associations**
Internal access to information (% of organizations that make information available to their members)	Basin	Limarí	75,0	**Maule**
		Maule	100	**Ñuble**
		Ñuble	87,5	**Limarí**
	User	Irrig. Assoc.	80,8	**Companies/Publ. Orgs.**
		Companies	100	**Irrigation Associations**
		Pub. Org.	100	
Links to community or users (% of organizations with active links with the community)	Basin	Limarí	92,3	**Maule**
		Maule	93,3	**Limarí**
		Ñuble	88,6	**Ñuble**
	User	Irrig. Assoc.	89,7	**Companies**
		Companies	100	**Irrigation Associations**
		Pub. Org.	80,0	**Public Organizations**

If indicators shown on Table 1 are grouped in broader categories according to the basin or users organizations (Tables 2 and 3), our results indicate that the Maule River basin shows the higher level of modernization in managerial processes of water resources. The Limarí River basin follows, while Ñuble is last.

Cuadro 2. Final categorízation of evaluation dimensions according to Basin

Category	Sum of scores by dimension		
Basin	**Dimension 1** Modernization of organizational mgmt.	**Dimension 2** Modernization of organizational culture	**Dimension 3** Development of participation mechs.
Limarí	14	13	8
Maule	20	8	8
Ñuble	11	9	4
Max Score	**21**	**15**	**9**
MinPuntaje Mínimo	**7**	**5**	**3**

Cuadro 3. Final categorízation of evaluation dimensions according to Users Organization

Category	Sum of scores by dimension		
User Org.	**Dimension 1** Modernization of organizational mgmt.	**Dimension 2** Modernization of organizational culture.	**Dimension 3** Development of participation mechs
Irrig. Assoc.	8	6	5
Companies	21	15	9
Public Orgs.	15	10	6
Max Score	**21**	**15**	**9**
Min score	**7**	**5**	**3**

Regarding the analysis by basin, Limarí shows the highest score in relation to organizational culture and practices, while regarding participation Maule and Limarí are best. Hence, Ñuble is behind in terms of modernization of all of these variables. Evaluation according to users suggest that private companies show the highest scores in relation to management of water resources, as well as in the development of organizational culture and participation. They are followed by public organizations and irrigators associations. This means that private companies are the users' organizations showing the highest levels of development and modernization of their organizational, productive, and economic activity. Hence, firms are organizations that have been able to develop complex managerial systems allowing them to achieve high efficiency in resource management and a better control of the planning process. They have also modernized their organizational culture with increased levels of flexibility and innovation thus being able to quickly adapt to external shocks. Finally, their internal participation mechanisms show a higher level of development, which are integrated with cooperation networks and exchange with the community.

The other organizations—users organizations, public organizations, irrigators associations—show lower levels of development in all of the variables mentioned above. These differences imply different abilities to manage water resources during, for example, climatic crisis. Private companies have developed a high capacity to manage all the set of analyzed variables and thus can handle associated risks in a better way.

Public organizations lag behind private companies. This may represent an opportunity (for the companies) and a risk (for public agencies) since the former can end up defining the way in which different resources need to be managed. In this sense, if the differences in organizational development become wider, the options to have a dialogue in technical matters are less.

D. List of publications and presentations arising from this project; please send reprints of journal articles as they appear in the literature.

- Lemos, M. C. and J. L. F. Oliveira (2004). “Can Water Reform Survive Politics? Institutional Change and River Basin Management in Ceará, Northeast Brazil. *World Development*, Vol. 32, No. 12, pp. 2121-2137.
- Lemos, M. C. (in press). “Whose water is it anyway? Water management, knowledge, and equity in NE Brazil”. *Water and Equity: Fair Practice in Apportioning Water among Places and Values*. Edited by Richard Perry, Helen Ingram, and John Whiteley, MIT Press: Cambridge, MA.
- Lemos M.C. “Are all water managers made equal? Climate forecast use across the institutional divide”. Under review at the *Bulletin of the American Meteorological Society (BAMS).*
- In addition, seven other articles whose focus relates to the subject of the project (and which uses the survey data) have been submitted for publication or are in preparation:
    - Lemos, M. C. and J. L. F. Oliveira (2005). Water reform across the state/society divide: the case of Ceará, Brazil. *International Journal of Water Resources Development*, vol. 21, no. 1, pp. 93-107.
    - Formiga-Johnsson, R., L. M. Kumler and M.C. Lemos (2007). The politics of bulk water pricing in Brazil: lessons from the Paraiba do Sul River Basin. *Water Policy*, vol. 9, no. 1, pp. 87-104.
    - Kumler L and M.C. Lemos. “Managing waters of the Paraíba do Sul basin: a case study in institutional implementation and change”. Submitted *Geoforum*.
    - “Factors shaping the use of technoscientific knowledge in water management in Brazil” (M. C. Lemos and Don Nelson)
    - Climate, knowledge and water management in Chile (A. Leon, F. Arcos, JM Arriaza, R. Fuster, and L.A. Montero)
    - Climate knowledge, water reform, and decision-making in Brazil and Chile: a comparative study (A. Leon, M. C. Lemos, and M. Keck).
    - Factors affecting the use of climate information in water management in Brazil and Chile (M.C. Lemos, A. Leon and D. Nelson).

E. Discussion of any significant deviations from proposed work plan.

Plans to start field research in 2003 had to be postpone because project funds were not delivered until Oct 2003. As a consequence, field work started in 2004 and a one year no-cost extension was requested from NOAA. The extension was granted but delivery of funds was again delayed and summer plans for 2005 had to be shortened. In consequence, the PI requested that some of the funds earmarked for field research be transferred to personnel. Notwithstanding, a small portion of the field budget remained unspent and has been returned to NOAA.

IV. Relevance to the field of human-environment interactions

A. Describe how the results of your project have furthered the field of understanding and analyzing the use of climate information in decisionmaking
(Text Limit: one page)

A.

- We expect the research on decision-making to generate both a data-base of decisions and non-peer reviewed publications that, by means of the comparison between two countries, highlight both the strength and weaknesses of the current institutional framework and dominant organizational culture;
- By focusing on the climate change dimension, we believe this project may have contributed to raise awareness and perhaps to the improved integration of climate information into the decision making process in both countries. Likewise, we expect to inform a wide array of stakeholders on the existence and potential of seasonal climate forecasts. Thus, in moving towards decentralization and integrated watershed management, we hope both countries will perform better with more informed and educated stakeholders.
- Finally, the project has produced (and will continue to produce) peer reviewed and other kinds of publications (i.e. river basin reports) that consider current forms of dissemination of drought and flood related information and their relevance (or lack thereof) for use of climactic forecasting information in policymaking and management of water resources.

B. This research builds on two previously NOAA funded projects about the use of seasonal climate information in Brazil (PI Maria Carmen Lemos) and a study comparing Brazil and Chile (PI Tim Finan). It also builds upon research on the use of seasonal climate forecasting by water managers in the United States (PI Steve Rayner) as well as on the CLIMAS regional assessment (RISA/OGP) (PI Jonathan Overpeck).

C. By building knowledge on the use of climate forecasts by a specific group of decision makers (water managers), this research will contribute:

   a. To understand how such actors use information or perceive potential use of this kind of information in the future. Detailed knowledge of data use, in turn, will improve understanding of adaptive capacity of different water-related systems (reservoir management, electricity, irrigation, etc) both to climate as well as to other stressors such as increased demand, multi-uses, etc.

b. To improve understanding of current institutional arrangements as a means to assess their ‘fit’, adaptability and effectiveness to plan and respond to global change. The study’s focus on institutional analysis in a comparative perspective (both within countries and across countries) has the potential to improve our understanding of the role of institutions (both formal and informal) and institutional adaptation in water management. This knowledge in turn, can critically inform the design and development of decision-making tools. Only by understanding how decision makers make decisions can we develop ‘usable’ tools.
c. To assess the role of climate information in policymaking and what can be done to expand and strengthen its influence in proactive governmental planning.

B. Where appropriate, describe how this research builds on any previously funded HDGEC research (i.e., through NSF, EPA, NASA, DOE, NGOs, etc.)

Work under this project built on a previous NOAA funded project of which Lemos and Leon were co-PIs (“Use and Usefulness: a Comparative Study of Seasonal Climate Forecasting Systems in Drought-affected Regions of Latin America”) and a NSF funded project for Lemos ("The Impact of the Use of Techno-Scientific Knowledge in Water Management: institutional adaptation and public participation in a comparative perspective).

C. How has your project explicitly contributed to the following areas of study?

This project was intended and designed to examine issues of high relevance for policy making systems. By improving our understanding of how climate information as well as other types of science-generated information is being used in water management in Brazil and Chile, findings from this project have the potential to contribute to at least six of the areas highlighted (adaptation to long-term climate change, natural hazards mitigation, institutional dimensions of global change, developing tools for decision makers and end-users, sustainability of vulnerable areas and/or people, the role of public policy in the use of climate information). For example, a simplified model of the formal and informal institutions shaping the use of technoscientific knowledge by water managers can support action to improve dissemination of climate information (who to target, at what level and how), inform boundary organizations about potential clients and the opportunities and constraints these clients face in using climate information, and support the interaction between knowledge producers and users. Moreover, understanding the role of technoscientific knowledge in decisionmaking processes and how it affects democracy within stakeholder councils can inform action to implement management institutions that may not only improve resource sustainability but also foster desirable values in public policy making implementation such as accountability, transparency and stakeholder participation in decisionmaking. These values are critical to guarantee sustainability not only of climate-vulnerable resources but also of social and governance systems using or managing those resources. For example, by carrying out an in-depth institutional analysis of technoscientific knowledge use in water management in the selected basins, this study contributes the literature on institutional dimensions of climate variability and change. It also has the potential to inform both disaster managers and policymakers about potential vulnerabilities and adaptive capacities on their designed response to climate variability and change. By shedding light on the factors that shape river basin committee's use of science generated information, policy makers can identify areas of strength and weaknesses in their goal of building governance system's adaptive capacity to future hazard.

D. Suggestions for Future Research: How could this research be applied/tested in other sectors or geographic areas? What are possible future collaborations with other government agencies or NGOs?

Because this project has been designed as a comparison at two levels, between basins within the same country and between basins across countries, we believe the methodological approach and assumptions can be applied to other countries and water systems with relative easy. Of course, any further comparison would have to take into consideration institutional variations and be adjusted in terms of the variables being focused upon. In fact, Lemos has already written an article (submitted to BAMS) comparing her findings in Brazil with findings from other NOAA funded projects in the U.S..

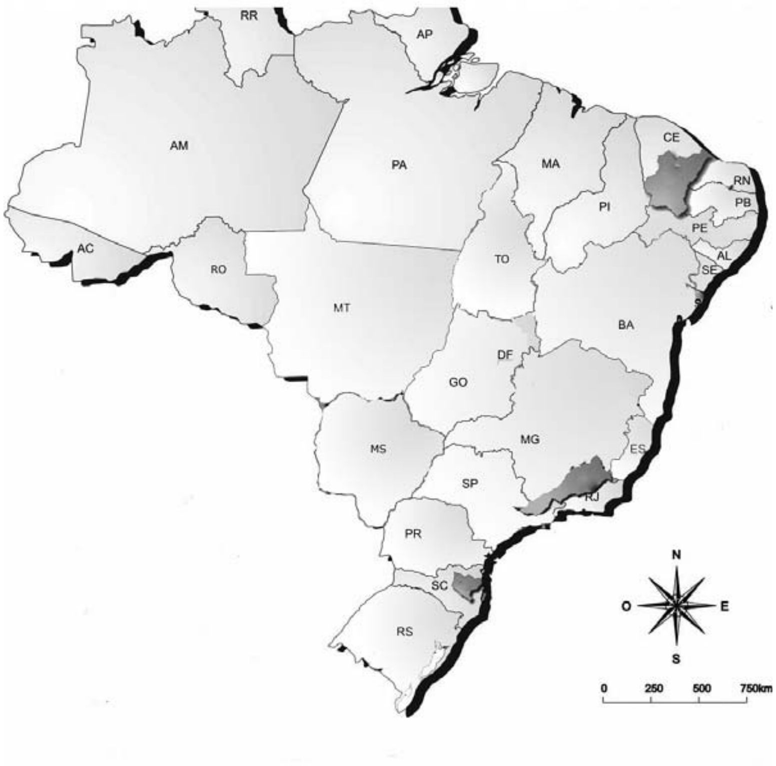
V. Graphics -- Please include the following graphics as attachments to your report:

A. Graphic depicting the overall project framework/approach

B. Graphic(s) depicting key research results

(see tables and graphics above).

C. Map of region covered by study (if applicable)



Map showing the Itajai, Paraiba do Sul and Lower Jaguaribe basins in Brazil

D. Photographs from fieldwork to depict study environment

References cited:

Lemos, M. C. 2003. "A Tale of Two Policies: the Politics of Seasonal Climate Forecast Use in Ceará, Brazil". Policy Sciences 32 (2):101-123.

Lemos, M. C., and J. L. F. Oliveira. 2004. "Can Water Reform Survive Politics? Institutional Change and River Basin Management in Ceará, Northeast Brazil". World Development 32 (12):2121-2137.

Levitt, B., and J. G. March. 1988. "Organizational Learning". Annual Review of Sociology 14:319-340.